

July 17, 1996

Dr. Martha Krebs  
Director  
Office of Energy Research  
U. S. Department of Energy  
Washington, DC 20585

Dear Dr. Krebs:

In your March 25 charge letter you asked FESAC to carry out an Alternative Concepts Review and in particular to "consider the fundamental investment strategy that we should use in funding alternative concepts." You specifically asked that the following issues be addressed:

- 1) Review the present status of alternative concept development in light of the international fusion program;
- 2) Produce an overall plan for a U.S. alternative concepts development program including experiments, theory, modeling/computation and systems studies, which is well integrated into the international alternative concepts program; and
- 3) Provide an interim assessment of the readiness of the spherical tokamak concept to move to "proof-of-principle" level experimentation.

Interim findings and recommendations with regard to the spherical tokamak assessment were provided in a letter to you in May. This letter and the report to be transmitted to you under separate cover respond to the first two alternative concepts charges.

In response to the charges, our Scientific Issues Subcommittee (SciCom) established in March an Alternative Concepts Review Panel, chaired by Professor Farrokh Najmabadi and including seven members of

SciCom plus additional experts from national laboratories and universities. Three prominent scientists from the international fusion community served as consultants to the Panel. The panel interacted with proponents of the various alternative concepts through a variety of solicited written input and presentations, and welcomed unsolicited input as well at a sequence of four meetings of the panel. They also set up a world-wide-web home page of alternative concepts assessment papers and input from the community. The FESAC wishes officially to thank the members of the panel for their work, and the alternative concepts researchers who provided such extensive input on relatively short notice.

As pointed out in FESAC's January 27 report on a restructured fusion program, the history of alternative concepts research has been rich in discoveries and innovations of significance to fusion plasma physics in general and tokamaks in particular. In addition, in a science-driven program with a constrained budget in the coming years, research on alternative concepts provides a special niche for the U.S. helping us maintain excellence and leadership in fusion research within the worldwide fusion program.

The Panel finds that a sound investment strategy for the fusion program includes a Concept Development Program (inclusive of tokamaks and alternatives) with emphasis on science and innovation. In order to develop an overall strategy, the panel developed four criteria to measure the benefit of the research. They are:

- 1) advancement of general plasma physics;
- 2) advancement of fusion plasma physics;
- 3) contributions to fusion energy development; and
- 4) development of candidates for fusion power plants.

The panel also provides a classification of alternative concept programs based on their maturity and size:

- 1) Concept Exploration;
- 2) Proof of Principle;
- 3) Proof of Performance and Optimization;
- 4) Fusion Energy Development; and
- 5) Fusion Demonstration Power Plant.

They also identified the required mix of experimental facilities, theory and modeling, and concept evaluation and power plant studies efforts at each level. The Panel notes that for programs at early stages of development, the major benefits of research are in advancing general and fusion plasma physics. At more mature stages, the emphasis shifts towards contributions to fusion energy development and power plants.

In devising an implementation of the envisaged strategy for alternative concepts research the Panel finds that such a program must consider many concepts, each of which has its own unique and challenging issues. These concepts span a wide range in terms of level of development. In such a program there is a need to base the program priorities on a strong scientific foundation. To this end, the Panel recommends forming a "Concept Development Panel" (CDP). This CDP can be a subcommittee of the FESAC to provide consensus scientific input and recommendations on the directions and priorities of alternative concepts research. This process is used in parts of NSF and NIH, and represents an experiment in community governance. If successful, it can be extended to cover the entire concept development program (including both tokamaks and alternatives).

The Panel reviewed the status of alternative concepts and provided detailed reports on five of the more developed ones. Until the CDP is constituted and charged with providing scientific input on priorities, the Panel provides the following recommendations for fiscal year 1997 (not in priority order):

- 1) Expansion of the Concept Exploration Activities to encourage science and innovation in alternative concepts;
- 2) Initiation of a proof-of-principle program in the spherical tokamak (ST) area, and construction of new ST experimental facilities;
- 3) Strengthening and broadening of the existing reversed field pinch (RFP) program;
- 4) An expanded stellarator program including theoretical studies, concept development, and collaborations on international experiments; and
- 5) Establishment of a vigorous theory activity in alternative concepts.

The Panel reiterates the point made in the FESAC report of January 27, 1996 that any alternative concept experiment "should be operated with healthy funding to operate cost-effectively." This policy coupled with the recommended activities for fiscal year 1997 has the potential to result in exciting scientific discoveries of significance for the mission and goals of the restructured fusion program.

Lastly, the Panel notes that programmatic and cultural distinctions exist between alternative and mainline concepts. These distinctions serve no useful scientific purpose and have caused considerable difficulties. The Panel and FESAC recommend that the OFES and the fusion community eventually remove these distinctions and focus on a seamless concept development program (including tokamaks and alternatives), with the decision to expand or reduce the research effort in any concept based solely on its contributions to the goals of the restructured fusion program.

The FESAC endorses the principles, processes and recommendations cited above and will transmit the full Panel report to you under separate cover.

Sincerely,

Robert W. Conn,  
Chairman on behalf of the  
Fusion Energy Sciences  
Advisory Committee

## **Charge to the Fusion Energy Advisory Committee for an Alternative Concepts Review**

In its report to DOE of January 27, 1996, the Fusion Energy Advisory Committee (FEAC) recommended that a review of Alternative Concepts be carried out as part of making the transition to a Fusion Energy Sciences Program. This review should fundamentally be directed at recommending an investment strategy for funding alternative concepts. What criteria, in addition to scientific excellence, should determine the effort devoted to the Alternative Concept Program (for example, similarity to or difference from the tokamak, power density, size, etc.)? Within the general guidelines of this recommendation, the Department requests the FEAC to organize and conduct such a review as expeditiously as possible, using whatever approach it deems most appropriate. Although FEAC recommended that inertial fusion energy (IFE) should be considered as part of the alternative concepts review, the Department recognizes the distinct characteristic of IFE and will request a review of IFE in a separate charge.

It is generally recognized that the various alternative concepts are at significantly different levels of development. Within this context, the review should address the following:

1. Review the present status of alternative concept development in light of the international fusion program. As part of this review, consider not only the prospects for alternative concepts as fusion power systems but also the scientific contributions of alternative concept research to the Fusion Energy Sciences Program and plasma science in general.
2. The review should produce an overall strategy for a U.S. alternative concepts development program including experiments, theory, modeling/computation and systems studies, which is well integrated into the international alternative concepts program. The U.S. plan and supporting documentation should include but not be limited to:
  - o recommendations on how best to collaborate in alternative concepts where our international partners already have large experiments (e.g., the stellarator),
  - o recommendations for encouraging new innovations in alternative concepts,
  - o a methodology for assessing on a comparative basis the scientific progress of alternative concepts in their early stages of development, and

- o a set of criteria for use in determining when an alternative concept is ready to undertake a "proof-of-principle" scale experiment. For this purpose, consider the Princeton Large Torus as the proof-of-principle experiment that validated the tokamak concept.

3. The spherical tokamak is recognized to be a scientifically advanced alternate. Based on the FEAC recommendations to enhance research on alternative concepts, the FY 1997 budget request contains proposed funding for the National Spherical Tokamak Experiment (NSTX) at Princeton. An experiment of this size and scope could be considered a "proof-of-principle" for this concept. There are several ongoing spherical tokamak programs and several new grant applications also under review. We are not asking you to review any specific proposals. Rather an assessment of the readiness of this concept to move to "proof-of-principle" experimentation would provide a useful example to be carried out early in the overall review process. This assessment should specifically address, in the international context, the present theoretical understanding and experimental data base of the spherical tokamak concept. In addition, the potential for such spherical tokamak research to resolve key physics and technology issues of importance to both the conventional tokamak and the spherical tokamak as a reactor in its own right should be considered.

The FEAC's findings and recommendations with regard to the spherical tokamak assessment should be delivered to the Director of Energy Research by mid-April. The overall review of alternative concepts should be delivered by mid-July.